Amendments to the Specification:

Please replace the paragraphs on page 1, line 1 – page 7, line 31 with the following:

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

European Patent Office Priority Application No. 02079757.7, filed 11/13/2002 including the specification, drawings, claims and abstract, is incorporated herein by reference in its entirety. This application is a National Stage of PCT Application No. IB2003/004752, filed 10/27/2003, incorporated herein by reference in its entirety.

BACKGROUND

The invention relates to a component placement machine with a frame and a ~~with a~~ transport device for transporting printed circuit boards in an X-direction~~, which transport device comprises at least one transport beam extending in the X-direction, which beam can be driven in the X-direction in a reciprocating movement~~. The invention further relates to a method for transporting printed circuit boards with respect to a frame ~~by means of a transport beam~~ in an X-direction using a transport beam.

~~Such a machine as well as such a method are disclosed in US-A-5.680.699~~ U.S. Patent No. 5,680,699 discloses a method and apparatus in which printed circuit boards in the form of strip shaped supports are ~~being~~ transported and are provided with electronic components. The strip shaped support or foil is on one lateral edge provided with holes through which transport pins of a transport beam are ~~being~~ inserted. The transport beam is further provided with a clamping mechanism that ~~which~~ extends along the other lateral edge of the foil. ~~By means of the~~ The clamping mechanism tautens the foil ~~is tautened~~ in an Y-~~directed~~ direction that extends ~~extending~~ perpendicular to the X-direction and lays ~~lying~~ in the plane of the foil. When the foil has been displaced in the X-direction over the desired distance, the clamping ~~means are being~~ mechanism is released, the transport pins are ~~being~~ lowered and the transport beam is displaced in a negative X-direction ~~whilst~~ while the foil ~~is lying~~ lays with its lower surface on a supporting plate forming part of the frame.

In view of the high accuracy with which components have to be placed, it is desirable to transport the printed circuit board ~~by means at~~ using a clamping mechanism ~~means~~. Furthermore, specific ~~no specific~~ transport holes do not need to be provided in the printed circuit board[[,]] so that more freedom in the design of the board is obtained. This machine is, however, not suitable for printed circuit boards that ~~which~~ are already provided with components on its lower surface.

SUMMARY

It is, therefore, ~~It is therefore~~ an object of the present invention to provide a component placement machine in which at least some of the above mentioned disadvantages ~~disadvantage has been~~ are overcome. ~~This object has been achieved by the component placement machine according~~ According to one embodiment of the invention, ~~in that the~~ a transport device is provided with a clamping ~~means~~ mechanism connected ~~to the~~ to a transport beam for clamping in at least one lateral edge that extends ~~extending~~ in the X-direction of the printed circuit boards to be transported.[[,]] ~~and in that the~~ The device is further provided with a supporting ~~means~~ mechanism connected to the frame for supporting two lateral edges on both sides of the printed circuit boards.[[,]] ~~which~~ The clamping ~~means~~ mechanism can be brought into an active clamping position such that the clamping ~~means are~~ mechanism is active during the movement of the transport beam in the positive X-direction and can be brought in a resting position ~~rest position~~ during return ~~returning~~ of the transport beam in the negative X-direction[[,]]. While the clamping mechanism is in a resting position the printed circuit boards are supported by the supporting mechanism. ~~in which rest position of the clamping means the printed circuit boards are being supported by the supporting means.~~

Because the printed circuit board ~~in the rest position of the clamping means~~, when the clamping mechanism is in a rest position, is being supported on the two lateral edges by the supporting ~~means~~ mechanism, the components connected to the lower surface of the printed circuit board do not form obstacles to ~~obstacles for~~ the supporting ~~means~~ mechanism. Furthermore, the supporting ~~means~~ mechanism on which the printed circuit boards simply rest, ~~do not~~ does not exert undesired forces on the printed circuit boards~~, due to which the~~

~~boards might be moved which~~ that might otherwise move the circuit boards. In this manner, a good ~~position~~ positional accuracy is obtained.

~~An embodiment of the component placement machine according to the invention is characterized in that~~ According to another embodiment of the present invention, the clamping ~~means comprise~~ mechanism comprises a fixed jaw portion, which cooperates with an upper side of the printed circuit board ~~and a moveable jaw portion~~, and a moveable jaw portion, which is movable in a Z-direction to the fixed jaw portion to cooperate with a lower side of the printed circuit board and which is movable away from the fixed jaw portion to release the printed circuit board. Due to the movable jaw ~~portion~~ portion, it is relatively easy to clamp a lateral edge of the printed circuit board. ~~Furthermore~~ Furthermore, by lowering the movable jaw portion with respect to the fixed jaw portion, the printed circuit board, which is resting on the movable jaw portion, is also lowered, whereby the lateral edges of the printed circuit board can easily be put on the supporting ~~means~~ mechanism connected to the frame.

According to another embodiment of the invention, ~~Another embodiment of the component placement machine according to the invention is characterized in that~~ the fixed jaw portion comprises a number of clamping elements ~~which~~ that extend in an X-direction one behind the other. The use of clamping elements with dimensions smaller than a dimension of each of the printed circuit boards will ~~achieve that~~ allow each of the printed circuit boards ~~will~~ to be continuously ~~always be~~ clamped in by at least two clamping elements. If the clamping element is spring loaded and comprises, for example a leaf spring, differences in thickness of the printed circuit boards will easily be taken into account.

~~Another preferred embodiment of the component placement machine according to the invention is characterized in that~~ According to yet another embodiment of the invention, the transport device comprises a bed of supporting pins, which are capable of moving ~~movable~~ simultaneously with the movable jaw portion. The supporting pins support the printed circuit board during transport and are located against the lower surface of the printed circuit board on locations where no components are present. Furthermore, the support pins prevent deflection of the printed circuit board. By simultaneously moving the movable jaw portion ~~as well as~~ and the supporting pins, a good support for the printed circuit board is obtained both during

the transport of the printed circuit board in the positive X-direction as well as during the lowering of the printed circuit board and placing it on the supporting ~~means~~ mechanism connected to the frame.

~~It is also an~~ Another object of the invention is to provide a method for transporting printed circuit boards whereby the transport beam can be returned to its initial position relatively quickly. This object is ~~being~~ achieved by ~~the method according to the invention in that~~ the simultaneous movement of the transport beam in the negative X-direction ~~as well as~~ and in the Z-direction ~~is partly simultaneously~~.

If the transport ~~beam is~~ beam has already ~~start~~ started moving in the negative X-direction before the transport beam has been displaced in the negative Z-direction over the predetermined distance, a time reduction is ~~being~~ obtained. The transport beam can be moved in the negative X-direction as soon as all the elements (of the transport beam), which might hit against components on the lower surface of the printed circuit board, are lowered enough to avoid collision. If ~~use is being made of~~ supporting pins are used, the supporting pins must be lowered to a ~~lower over~~ safety distance that ~~which~~ is larger than the height of the biggest component connected to the lower surface of the printed circuit board. This safety distance therefore depends on the specific printed circuit board that ~~which~~ is provided with components in the component placement machine. The safety distance is, therefore, preferably adjustable. In the same manner, the transport beam can be moved in a positive Z-direction from the predetermined distance to the safety distance as soon as the transport beam is near its initial position. As soon as the transport beam is at its initial position in the X-direction, the transport beam can be moved upwards and the supporting pins can be brought ~~are brought~~ against the lower surface of the printed circuit board.

The invention will now be explained in more detail below with reference to the ~~drawing~~ drawings, in which embodiments of the component placement machines according to the invention are shown by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the present invention will become apparent from the following description, appended claims, and the accompanying exemplary embodiments shown in the drawings, which are briefly described below.

Fig. 1 ~~shows~~ is a front view of a component placement machine according to the invention[[,]].

Fig. 2 ~~shows~~ is a schematic side view of the machine as shown in Fig. 1. ~~fig. 1,~~

Fig. 3 shows a detailed part of the side view shown ~~as shown~~ in Fig. 2. ~~fig. 2.~~

Fig. 4 shows several steps for transporting printed circuit boards ~~board~~ according to one embodiment of the invention.[[,]]

Fig. 5 shows a graph of the movement of the transport beam of the machine as shown in Fig. 1. ~~fig. 1.~~

DETAILED DESCRIPTION

Fig. 1 shows a component placement machine 1 according to one embodiment of the present invention ~~the invention which~~ that is provided with a frame 2 in which a transport device 3 is accommodated. The component placement machine 1 is further provided with a number of component placement units 4. Such component placement units 4 are known for example from the above mentioned ~~US patent US-A-5.680.699~~ U.S. Patent No. 5,680,699. A plurality of printed ~~Printed~~ circuit boards 5 can be transported through the machine 1 by the transport device 3. The transport device 3 can be indexed over a certain distance in a positive X-direction by driven means (not shown), whereupon the transport device 3 can be moved back into its initial or starting position in the negative X-direction after said distance has been covered. The printed circuit boards 5, transported by means of the transport device 3, are provided with components by the component placement units 4.

Figs. 2 and 3 ~~Fig. 2 and 3~~ show a side view of the component placement machine 1, ~~and especially~~ specifically the transport device 3. The transport device 3 comprises a

transport beam 6, which comprises two plates 7, 8 extending parallel to each other. The plate 7 is movable with respect to the plate 8 in and opposite to the Z-direction. The plate 7 carries a plate 9 on which supporting pins 10 are mounted. On one lateral side, the plate 7 is provided with a metal sheet 11 ~~extending~~ that extends perpendicular to the plate 7. An edge 12 of the metal sheet 11 lies at the ~~on the~~ same height as the ends of the supporting pins 10. The plate 8 of the transport beam 6 is provided on a lateral edge with a plate 13 that extends ~~extending~~ parallel to the metal plate 11. The plate 13 is ~~slidable~~ slidably mounted with respect to a guiding strip 14, which is connected to the frame 2. As can be seen in ~~fig. 3~~ Fig. 3, the plate 13 is ~~thereto~~ provided with a set of wheels 15 forming a guiding ~~means~~ mechanism with respect to the guiding strip 14. By means of the slidably ~~slidable~~ mounted plate 23, the guiding strip 14 will be positioned in the Y[[-]] and Z-directions.~~Z-direction. By means of~~ Due to the slidably mounted plate 13, the whole transport beam 6 can be moved in, and opposite to, the X-direction.

The plate 13 is provided on a side remote from the plate 8 with a part 15 that extends ~~extending~~ parallel to the plate 8 and above the edge 12 of the plate 11. The part 15 forms a first jaw portion that cooperates ~~cooperating~~ with the edge 12 forming a second jaw portion of a clamping ~~means~~ mechanism. Between said jaw portions 12, 15 the printed circuit board 5 can be clamped. The part 15 is, as can be seen in Figs. 3 and 4, ~~fig. 3 and~~ 4, provided with a number of clamping elements 16 ~~which~~ that extend in an X-direction one behind the other and are connected by means of leaf springs 17 to the part 15.

On a lateral side remote from the knife shaped thin plate 11, a relatively thin plate 25 is mounted on the plate 9. The plate 25 ~~which plate 25~~ extends to the same height as the ends of the supporting pins 10. According to one embodiment of the invention, the ~~The~~ plate 25 supports a components free lateral zone of ~~for example~~ 3mm. ~~of the printed circuit board 5.~~

The guiding strip 14 is on a side directed to the part 15 ~~the part 1S~~ provided with a ridge 18 forming part of a supporting ~~means~~ mechanism for the printed circuit board 5. The supporting ~~means~~ mechanism for the printed circuit board 5 further comprises ~~furthermore~~ an element 19 ~~which~~ that is movable in and opposite to the Y-direction in order to ~~be able to~~

support printed circuit boards 5 with different widths. ~~width.~~ The element 19 is provided with a ridge 20 ~~lying on~~ lying at the same height as the ridge 18.

The element 19 is further ~~furthermore~~ provided with a spring loaded element 26 which presses the printed circuit board 5 against the plate 25. During transport, the printed circuit boards 5 slide along the spring loaded element 26.

The operation of the machine will now be explained with reference to ~~fig.~~ Fig. 4 in which several steps, I-VI, are shown for transporting a printed circuit board 5. In step I, three printed circuit boards 5 are located in the machine 1 and are resting with their lateral edges on the ridges 18, 20 of the supporting mechanism. ~~means.~~ The plate 7 of the transport beam 6 as well as the plate 11 connected thereto is located in a relatively low position whereby the edge 12 is located under the level of the ridges 18, 20.

In step II, the plate 7 of the transport beam 6 together with the plate 11 and the supporting pins 10 has been moved in the positive Z-direction whereby lateral edges 21 (see Fig. 3~~see fig. 3~~) of two boards 5 are clamped in between the edge 12 of the plate 11 and the clamping elements 16[[,]].

The lateral edges of the printed circuit board necessary for being supported and being clamped should ~~in need to~~ be free from components. This component-free lateral zone ~~is for~~ may be, for example, a length of 3 mm.

As can be seen in ~~fig.~~ Fig. 4, each printed circuit board 5 is clamped in by several clamping elements 16, the length of which ~~being~~ are smaller than the longitudinal dimension of the printed circuit board 5. ~~It is achieved thereby that~~ Thus, each of the printed circuit boards 5 will be satisfactorily ~~be~~ clamped in place by at least one clamping element 16 in spite of possible thickness differences among the printed circuit boards 5. ~~As can be further seen~~ Further, in step II, the printed circuit board 5 on the right side is being removed from the machine 1, for example by means of an endless belt 22 as shown in ~~fig. 1~~ Fig. 1.

In step III, the transport beam 6 together with the clamped in circuit boards 5 ~~is transported~~ are transported in the X-direction. The transport in the X-direction ~~can be~~ may be

stepwise so that each printed circuit board 5 will stop under each component placement unit 4 to provide it with components. Before a component is placed on the printed circuit board 3, the exact position of the board 5 with respect to the component placement unit 4 can be determined by means of a camera mounted on the unit 4.

In step IV, the transport beam 6 has reached a position in which a printed circuit board 5 is located near the end of the transport device 3. A new printed circuit board 5 can now be brought in by means of, for example an endless belt 23 (see ~~fig. 1~~ Fig. 1).

The transport beam 6 is provided near the left side with a stopper 27 to which the new printed circuit board 5 transported by the endless belt 23 will abut. As soon as the new printed circuit board 5 is near the stopper 27, an optical sensor 28 will detect it and send a signal to the ~~driven~~ driving means of the endless belt 23 to reduce its speed so that the board 5 will slowly abut against the stopper 27. The stopper can be displaced from the left side to the right side in case ~~that the~~ the machine 1 is ~~will be~~ driven in the opposite direction. On the right side 29, an optical sensor 29 is also mounted on the transport beam 6. By means of said optical sensor 29, it is possible to detect a printed circuit board 5 on the right side of the transport beam 6. If said printed circuit board 5 has not yet been removed and is detected by the optical sensor 29, upward ~~an upward~~ movement of the transport beam 6 can be stopped to prevent damage to the machine 1 and/or the printed circuit board 5.

As shown in step V, the plate 7 together with the plate 11 and the transport pins 10 ~~is moved~~ are moved in the negative Z-direction whereby the printed circuit boards 5 will also move downwards until the lateral edges of the printed circuit board 5 abut the ridges 18, 20 of the supporting ~~means~~ mechanism and will rest thereon. Now the transport beam 6 can be moved in the negative X-direction until it has reached the initial position as shown in step I. The cycle of transporting printed circuit boards 5 ~~can now~~ may now be repeated. ~~started again.~~

In ~~fig. 5~~ Fig. 5, a graph is shown in which the movement of the transport beam 6, ~~and especially~~ the plate 7 and the metal plate 11 connected thereto is shown. First, the transport beam 6 is indexed in several steps S1, S2 and S3 to transport the printed circuit boards 5.

Then, the plate 11 is moved in the negative Z-direction to a safety distance at level Zsafe, on which level, the supporting pins 10 are located below all components 24 connected to the lower surface of the printed circuit board 5. As soon as the plate 11 and the supporting pins 10 ~~has reached~~ have reached the level Zsafe, the transport beam 6 ~~start~~ start moving in the negative X-direction ~~whilst~~ while the plate 11 continues moving in the negative Z-direction until it has reached the level Zmin. Due to this combined movement, the time necessary for the movement of the transport beam 6 back to the initial position is reduced. As soon as the transport beam 6 reaches ~~it initial~~ its initial position, the plate 7 and the plate 11 are ~~being~~ moved upwards to the level Zsafe. When the transport beam 6 ~~transport beams 6~~ has reached its initial position, the plate 11 is moved beyond the Zsafe level to the initial Z0-level on which the printed circuit board 5 is supported by the transport pins 10 and clamped in between the edge 12 of the plate 11 and the spring loaded clamping elements 16. Also, due to the combined movement in the negative X-direction and the positive Z-direction near the initial position of the transport beam 6, a reduction of the time necessary for the return movement of the transport beam 6 has been achieved.

~~The positive X-direction can be directed to the right side of the machine 1 as well as to the left side.~~

~~The predetermined position to which the transport beam 6 is indexed is programmable. Also the steps S1, S2 etc. are programmable.~~

~~It is also possible to clamp in the painted circuit boards 5 on both lateral edges during transport.~~

Further, in some embodiments the positive X-direction can be directed to the right side of the machine 1 as well as to the left side. The predetermined position to which the transport beam 6 is indexed may be programmable. Also, the steps S1, S2 etc. may be programmable. It is also possible to clamp in the printed circuit boards 5 on both lateral edges during transport.

Given the disclosure of the present invention, one versed in the art would appreciate that there may be other embodiments and modifications within the scope and spirit of the

invention. Accordingly, all modifications attainable by one versed in the art from the present disclosure within the scope and spirit of the present invention are to be included as further embodiments of the present invention. The scope of the present invention is to be defined as set forth in the following claims.